STUDIES IN DISEASES OF ORNAMENTAL PLANTS

II.

THE STEM EELWORM (TYLENCHUS DIPSACI (KÜHN) BASTIAN) OF NARCISSI

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The Stem Eelworm (*Tylenchus dipsaci* (Kühn) Bastian), of Narcissi

Almost eighty years ago this minute eelworm, or nematode, was described in Germany by Kühn, who observed it in the flowering heads of teasel (Dipsacus). The first name given to it was *Anguillula dipsaci*. On finding it in other hosts, such as rye, buckwheat, clovers, etc., Kühn changed the specific name into *A. devastatrix*. Ritzema-Bos later changed the genus into *Tylenchus*. *Tylenchus devastatrix* and *T. dipsaci* are now regarded as synonymous, the latter designation being valid.

It has now become known that the stem eelworm is capable of attacking a wide range of host-plants; at least 67 species of 24 genera have been recorded as susceptible. As the popular name indicates, this eelworm does not attack the roots of plants. In Canada and the continent of North America it has been found occasionally, certain reports indicating destruction of strawberry plants in Oregon. It is advisable, therefore, to keep a sharp lookout for a pest that is very annoying and most difficult to control once it has become established.

Recently stem eelworm occurred off and on in cut narcissi grown in greenhouses, and, since there is difficult access to descriptions of this trouble, the opportunity afforded by the receipt of typical material in flowering narcissi is made use of in these notes.

ORIGIN OF INFECTION OF NARCISSUS

First of all, there is little doubt, that most narcissus infestations originate from affected narcissus bulbs. While in an advanced stage the trouble is easily recognized in the bulb, slight infections escape even the most conscientious inspection. Such cases, then, are responsible for finding eventually the typical lesions in growing plants.

Now these nematodes are exceedingly minute. No one can detect the worms themselves, unless a microscopical examination is made of all suspicious cases, which is impractical for the layman. Fortunately the trouble can be recognized by very characteristic symptoms in the bulbs and later in the plant itself. The symptoms may be conspicuously prominent, with a wide range of variation, to very slight, in which case they are generally so insignificant as to escape detection or to appear not worth bothering about, which is a mistake. Very badly infected bulbs are soft, spongy and, on cutting across, show dark brown rings between the scales (see Plate 1, A and B); or a large number of scales completely discoloured and decayed. Curiously enough, in such material the eelworms are scarce; they are said to be very sensitive to changes in cell sap; on the other hand large numbers of brown-legged and snouted mites (*Rhizoglyphus echinopus*) and their large sized eggs, semi-parasitic eelworms of all kinds, as well as quite a number of fungi may be detected. Bulbs in this condition, when planted, as they frequently are, by the unsuspecting amateur, do not grow, but decay. According to the degree of infection, plants grown from such bulbs do not produce the desirable long straight foliage and flowering stems, but are peculiarly lopsided, curved and twisted. Serious contortions are absent when the attack is slight.

An indication of this mode of growth is represented by Plate I. Naturally plants of this type are easily recognized and rarely are fit for use. Indeed their blooms are not fit to cut for sale and it is easily understood that every

such bulb constitutes a loss to the growers, considerably in excess of the value of the bulb. From these more prominent stages of infection we come to those which have frequently given rise to complaints and yet are difficult to detect, unless one is familiar with the eelworm trouble. Thus in some plants only a few leaves may be involved; in others leaves and flower stalks; in others again only one or more lesions may occur (Plate 2).

EELWORMS DIFFICULT TO CONTROL

Stem eelworms, because of their capacity of affecting a host of economic plants are, elsewhere—and may prove to be here—a very serious pest, such as a somewhat related form (*Heterodora radicicola*) affecting roots of cucumber, tomato, phlox, peony, etc. with which growers have become unfortunately only too familiar. These latter nematodes are known to affect over 500 species of plants; they are, moreover, difficult to destroy once they are in the soil, for soil sterilization, which in the best circumstances is a bothersome process, would have to be resorted to as one means of control. This species may also be starved out and will soon die in dry soil, especially in the absence of food plants. In moist soils they remain alive much longer and apparently can live longer without food.

Since experience with *Heterodora* has taught its lesson, it is obvious that stem eelworm attacks should not be neglected. Growers should realize the potential dangers from this stem eelworm to their own cultures. At a time when a pest has not become too widespread or universal, special precautions are advisable, and the present is the time.

SYMPTOMS AND DESCRIPTION OF EELWORM ATTACK IN NARCISSUS

Our illustration (Plate 1) shows typical, more or less slight infections of flowering stems and leaves. Some of them may not escape detection, although one would be ignorant of the cause, while others, even a careful person, may not recognize, unless he is specially trained to be critical. Oftentimes, only one or two lesions may be present on a leaf, in which cases, there is usually only a slight curve in that portion of the leaf, with the centre towards the lesion. Apparently normal expansion of the leaf is interfered with at this place, thus, while keeping on growing along the outside of the lesion, a curve will be the result. Equally, should there be three or four lesions in fair proximity, the leaf may become considerably twisted in trying to overcome the nuisance. (Plate 2.).

The nematode lesions are really small galls, inhabited by the eelworm family, which possesses a most alarming fecundity, and a suitable specimen may yield every stage in their development, from eggs within the female, to large numbers of free eggs with worms in all stages, finally those strenuously attempting to break the egg shell and become free, or actually in the course of hatching. Thus a microscopical preparation may reveal eelworms and the larvae of their young in all sizes up to adult specimens reaching almost across the entire field of vision using medium magnification. Preparations are usually obtained from a maceration of the gall by scraping with a scalpel. In many instances only very few, if any, eelworms are discovered in fresh galls, but the eggs are usually present; if kept in a moist chamber, for a day or two, however, the galls become spongy and can easily be scraped off. When placed into a drop of water and examined with a microscope one finds disintegrated, enlarged, free floating host cells, evidently the pectic substance of the middle lamella glueing the cells together has been dissolved, present among which there is quite a collection of eggs and wiggling eelworms. When plentiful, it is possible to observe these readily in such a preparation with a hand lens giving 20 diam. magnification, by viewing the preparation against transmitted light.

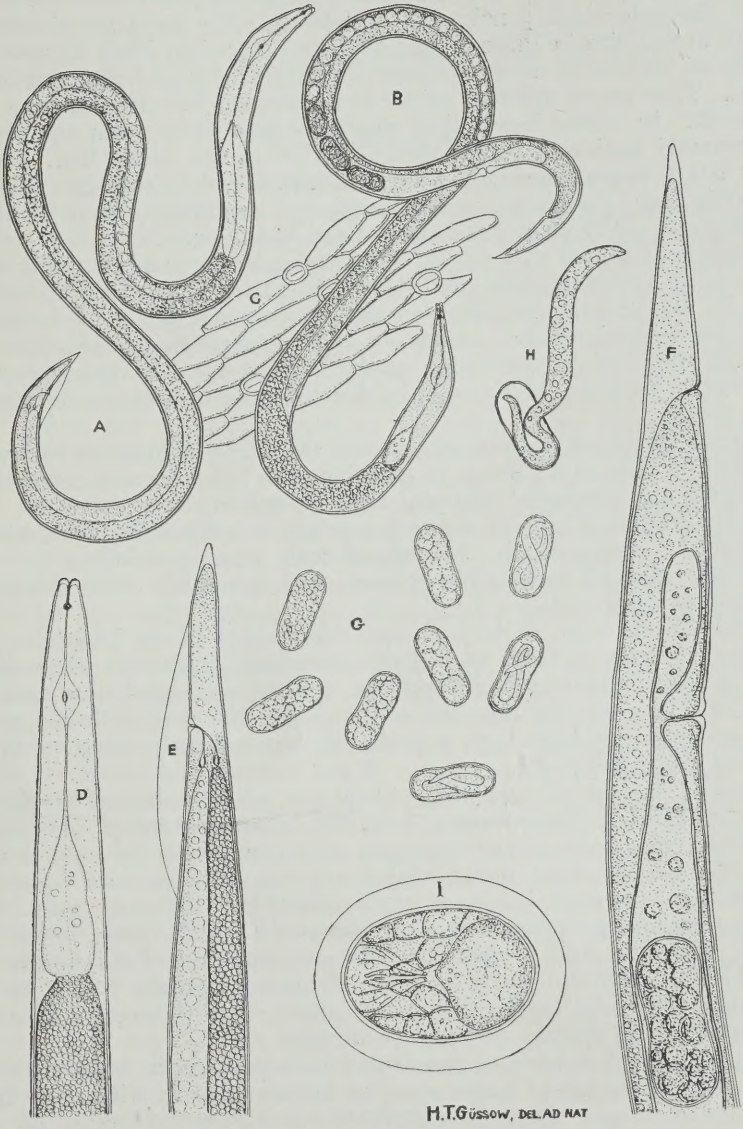

PLATE III.—(A) Male adult of *Tylenchus Dipsaci*.. (B) Female adult of *Tylenchus Dipsaci*. (C) Epidermal cells of narcissus leaf, same magnification as adults. (D) Head of *Tylenchus Dipsaci*. (E) Tail end of male eelworm. (F) Tail end of female eelworm. (G) Eggs at different stages of development. (H) Hatching larva—note immediate increase in size. (I) Egg of *Rhizoglyphus echinopus* mite; identical magnification as eelworm eggs.

The eelworm galls vary in size and are somewhat shiny or glossy on the surface. Usually they occur singly, rarely are they confluent. The plant, evidently in an attempt to isolate this centre of irritation, produces series of specialized cells, through which penetration is difficult. The galls are shown slightly more than actual size in Plate 2, and slightly reduced in Plate 1, but from the knowledge of the size of normal foliage the natural size of a gall can be readily estimated. They are of different colour to the normal leaf, frequently a different tint of green. In fading leaves they retain their peculiar green and thus stand out prominently against a background of yellow of the fading leaf. They may be easily felt between finger and thumb as insignificant swellings. The trouble seems particularly prominent under greenhouse conditions, or in bulbs forced by the amateur, although it has been noticed in the open.

In examining plants with curved and twisted leaves one invariably discovers numerous mites (*Rhizoglyphus*) and their eggs, particularly where leaves are still enclosed by the sheath, and between the leaves towards the mid rib. These mites, we are assured, are only secondary and not parasitic like the eelworm, but most likely they aid in destroying affected bulbs more quickly. Some more work, however, on these mites should be done in order to be quite certain of their harmless nature.

Material suspected of eelworm attack should be submitted to an expert; we too shall be glad at all times, to examine such material and definitely assist in identifying any suspected material that is sent to us.

Our illustration (Plate 1) shows a portion of a flowering stem with many lesions and the characteristic twisting of both stem and foliage.

It is felt that all responsible growers will appreciate these hints and do their utmost to exercise care.

Furthermore in view of the fact, that there exists in the Dominion a growing interest in bulb culture, and that infestations with this nematode have occurred in recent years in such localities, growers are urged, that, unless they will proceed with care, the eelworm will seriously interfere with the prosperity of their undertaking, indeed, it is probable, put an entire stop to the growing of good narcissus bulbs.

A similar species of eelworm, possibly a mere biological strain, causes injury to hyacinths. The eelworm, however, infesting narcissi does not affect hyacinths and vice versa, hence these two crops may safely be used in rotation.

There is not the least doubt that the original infestations resulted from infested bulbs. Growers increased their stock, but did not study carefully insect pests, animal parasites and plant diseases likely to cause losses to their enterprise, hence we find to-day that diseases and pests have become established, which it will take years to fight. It is not too late to-day to issue a warning that successful bulb growing in Canada is very largely, if not exclusively, a question of disease and pest prevention.

The phenomenal success of the Dutch bulb growers is largely due to the fact that they have passed years ago the initial stage in which we find ourselves at the moment. They have realized the ravages of pests and diseases and growers of repute produce excellent bulbs for export. Unfortunately, in all countries, there exist a number of less careful men, who produce cheap bulbs, and it is here where the Canadian importers commit an error in judgment, cheap bulbs, while not always are often scrub bulbs and not worth the money spent on them. It is an indisputable fact that cheap bulbs contain the largest amount of "duds" and are responsible largely for the introduction of pests and diseases. Prospective growers are therefore advised to start right with planting stock and insist upon a guaranty that they obtain bulbs from firms whose cultures are free from eelworms and for that matter from other pests and diseases. Those familiar with the very rigid inspection of growing bulbs of all kinds as practised in Holland and Great

Britain, know that this method alone will produce good returns, and any Canadian bulb growing enterprise should so be built up. Where planting is left to inexperienced, cheap labour, diseases and pests are not eliminated, but actually propagated, and an industry which promises to be quite sound in its conception in certain localities is doomed from the start. This cannot be too emphatically stated.

CONTROL MEASURES

Consignments of narcissus bulbs are carefully inspected on arrival in Canada by qualified inspectors of the Department. Frequently whole shipments have been condemned when the noticeable infection went above a certain standard. Since it is impracticable to examine every individual bulb, there is every prospect, that slightly infected bulbs may be released. Moreover, home grown bulbs are not subjected to compulsory inspection and since this nematode has given trouble in some parts of the country, growers are advised to discard any suspicious looking bulbs and only use fresh, clean, firm bulbs. Should the presence of an infestation become known we strongly urge resorting to hot water treatment of the bulbs before planting them.

Where care has been taken, this somewhat troublesome treatment will never become necessary, but we have evidence that a good many growers have had their cultures invaded by this pest, and the only means of success in the future will depend upon this treatment being carried out carefully and systematically. Unless this is commenced in the immediate future and continued together with other precautions relating to rotation or soil sterilization —until this pest is under control, my advice is to make a fresh start, which is cheaper in the long run.

In hot water treatment bulbs are soaked in wire baskets or loose sacks for three to four hours, according to the size of the bulbs, in water kept at a steady temperature of 110°F, it should never rise above 111·5°F. A very reliable thermometer should be used and the time should be reckoned from the minute the water has reached 110°F. after placing the bulbs into it. The treated bulbs must be carefully and gradually cooled after treatment, this is very important, or the flowering will be affected. Neither should the treatment be done too long ahead of actual planting time, or the bulbs will not produce bloom. When cool, they may be dried in air currents and are then quite free from living eelworms. Incidentally this treatment also destroys the larvæ of the Narcissus fly. No injury whatever will result from careful treatment providing the bulbs were thoroughly ripe—whether large or small—and completely dormant. Propagation stock from which usually no flowers are expected does not require so careful manipulation in after treatment as flowering stock. Nothing of course, can be done once the eelworm is present in leaves or flower stems. All infected plants, bulbs and all, should be destroyed by fire.

Every responsible grower, whether in greenhouses or outdoors, but especially the latter, should institute a system of field inspection and remove systematically as soon as noticed, any bulb, root, (and immediately surrounding soil), that shows the least sign of any trouble, whether eelworms, or blight of any kind and in any kind of bulbs grown. This method may be costly to some growers at present, but is the only means leading to success in establishing an enviable reputation for themselves and the bulb growing industry of Canada generally. Young industries least of all, can afford taking chances.

As will be seen from above remarks success of the growing of bulbs of any kind will depend upon the use of bulbs free from pests and diseases which is the most fundamental precaution. Where necessary, the bulbs should be treated with hot water, but neither method releases any grower from the necessity of practising rigid field inspection.

In conclusion reference is necessary to the treatment of infested soil and fields. The life history of various kinds and genera of eelworms has been studied for many years, but much empirical advice has been given and put into practice. Some eelworms are controlled more easily than others. In amateur gardens eelworm is and will remain a perfect nuisance, since most of them affect a wide host range of plants including weeds of all kinds. Rotation and soil sterilization, once eelworm infestations exist are impracticable, generally, in private gardens. Here one would rely upon judicious feeding of affected plants, potash fertilizer being specially recommended, to make good the drain on the life of the plants, by the ravenous parasites feeding on its roots.

The commercial grower, however, will be able to take several precautions that will lead to ultimate success.

The experienced greenhouse specialist will refrain from using soil used for forcing of any kind of bulbs (and any greenhouse crop for that matter) over and over again, since pests and diseases of all kinds are bound to accumulate in these, generally rather fertile soils. Soils should be removed, preferably every year, and a supply of good soil should be available by a grower with foresight.

Refrain from spreading used soil over the grounds outdoors, unless it may be used as top dressings for lawns; in mild climatic regions this former practice has caused infestation of outdoor grown plants. The tomato and cucumber root gall producing nematode (*Heterodora radicicola*) has thus given rise to bad infections of potatoes and hundreds of herbaceous perennials grown outdoors. Frost apparently has little effect upon the life of many eelworms and should not be considered as a reliable factor.

Heat in any form, on the contrary, is a very effective medium for the destruction of almost any eelworm pest known. Dry heat or steam are both effective. And infested soil should be sterilized under all conditions. Steam sterilization is the most effective, and if properly employed an exposure of one minute only is required to destroy even the most resistant stages of eelworms, including the egg cysts of the very destructive form of *Heterodora Schachtii* which in some countries causes havoc amongst sugar beet cultures. Good success has been obtained from thorough drying out of the greenhouse soil for at least a year, this method apparently starves out the pests.

In the case of infested field soils the problem becomes more difficult, steam sterilization of freshly dug up seed beds or any limited plots may be possible and advisable under special circumstances, but general field areas cannot so be dealt with and the only recourse is to extended rotation, with plants that do not act as hosts and will thus starve out the pest in time. Starving out by these means is a very doubtful practice, especially should ever the sugar beet eelworms become established, the cysts of which have resisted starvation for five years. Generally speaking a four-year rotation should be practised, but since this depends largely upon the kind of eelworm present, it is well to secure special advice in each case. In the case of the stem eelworm of narcissi, which does not produce root galls or cysts, but is free living, a four-year rotation has been quite beneficial, avoiding any of the plants mentioned in the list below.

Since eelworms do not penetrate to any great depth in the soil, summer fallowing might well be resorted to, keeping the soil perfectly free from all weeds and maintaining a constantly soft mulch to the depth of five or six inches, so that they may be thoroughly dried out. After each rain cultivation should be practised on fallow lands without delay.

Another means to free the soil gradually from eelworms is suggested by the use of a host serving as "trap plant" for the eelworms. Under Canadian conditions we recommend that rye be thinly sown in fall and that the plants

be "dragged out" of the ground in spring by any suitable kind of harrow, the roots to be piled and burned when dry. This procedure followed by summer fallow will do much towards more quickly restoring soil conditions suitable for bulb growing. Hyacinths or lilies may then follow a summer fallow if the last crop was of narcissi, or vice versa.

It will be seen from the above remarks that the elimination from the soil of eelworm is a tedious process. It is quite possible, if instructions are closely followed, but it is far more reasonable for any prospective grower to practise the wisdom of prevention from the start.

PROVISIONAL LIST OF PLANTS KNOWN TO BE ATTACKED BY STEM EELWORM

Reference has been made to the case of stem eelworms affecting the narcissus and hyacinth; these evidently constitute different strains, since the narcissus eelworm does not affect hyacinths and vice versa. The following list of plants includes European and American data. The question as to how many different strains may exist, has not been solved; there is every indication, however, of such specialization; nevertheless knowing that the following plants have actually been observed as subject to eelworm attack, it is advisable to take no chances and to refrain from including into one's rotation any of the economic plants referred to and to eradicate promptly any of the weeds mentioned:—

Cereals: Barley, oats, rye and wheat.

Clovers and Grasses: Alfalfa, red clover, crimson clover; sweet vernal *(Anthoxanthum odoratum)*, Yorkshire fog *(Holcus lanatus)*, perennial ryegrass *(Lolium perenne)*, annual bluegrass *(Poa annua)*, green foxtail *(Setaria viridis)*.

Leguminosae: Peas, beans, vetch, lupine (?).

Field and Root Rot Crops: Potatoes, onions; flax, hemp, rape, buckwheat.

Garden Crops: Strawberries; and the following species of *Fragaria: F. vesca, F. virginiana, F. platypetala, F. chiloensis; Aucuba japonica, Anemone japonica, Narcissus Tazetta, Phlox decussata, Primula sinensis, Hyacinthus orientalis, H. romanus, Scylla campanulata, S. cernua, S. sibirica, Allium* species.

Miscellaneous and Weeds: *Anagallis arvensis, Bellis perennis, Centaurea Cyanus, C. jacea, Chelone glabra, Dianthus Caryophyllus, Dipsacus fullonum, D. sylvestris, Disa grandiflora, Galtonia candicans, Geranium molle, Myosotis stricta, Plantago lanceolata, Polygonum Convolvulus, P. lapathifolium, P. Persicaria, Ranunculus acris, Sonchus oleraceus, Spergula arvensis, Capsella Bursa-pastoris.*

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I. The Yellow Disease of Hyacinths,
by F. L. Drayton, Pamphlet No. 104, New Series.

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